# California Environmental Protection Agency

# Air Resources Board

PERMEATION RATES OF SMALL OFF ROAD ENGINE HIGH - DENSITY POLYETHYLENE FUEL TANKS (FEBRUARY 2001 TESTING)

Engineering and Certification Branch Monitoring and Laboratory Division

June 8, 2001

#### PERMEATION RATES OF SMALL OFF ROAD ENGINE HIGH - DENSITY POLYETHYLENE FUEL TANKS (FEBRUARY 2001 TESTING)

#### Introduction

The California Air Resources Board (CARB) staff tested twelve High-Density Polyethylene (HDPE) fuel tanks to determine their permeation rates. Tanks were preconditioned with commercial fuel, refilled with Phase II California Reformulated Certification (CERT) fuel, and subjected to a variable temperature profile. Permeation rates were then determined gravimetrically during the month of February.

#### **Test Protocol**

In January, the untreated tanks used with 4-cycle engines underwent the preconditioning process using commercial fuel, per CARB Test Method 513. Untreated tanks used with 2-cycle engines underwent the preconditioning process using a 2% commercial fuel/oil mixture. The tanks were stored at ambient temperature and pressure in flameproof storage cabinets. After four weeks of ambient preconditioning, the tanks were emptied; dried with compressed zero air, and immediately refilled with either CERT fuel or a 2% CERT fuel mixture. The tanks were then sealed using a hand held fusion welder and 1/4" thick HDPE coupons and leak tested as specified in Test Method 513 (a copy can be found at the CARB web site: http://www.arb.ca.gov/regact/spillcon/spillcon.htm).

Weight loss was used to determine relative permeation rates. Sealed tanks were weighed using a 16,000 gram or 6,200 gram balances with sensitivities of  $\pm 0.1$  and  $\pm 0.01$  grams respectively. After each tank was weighed, the weight was recorded. They were then placed in the Sealed Housing for Evaporative Determination (SHED) and exposed to a 1-day/24-hour/1440-minute variable temperature profile (see Attachment 1). This profile is considered our diurnal cycle (recurring every day). Tanks were then post weighed after each 24-hour diurnal cycle and the weight loss calculated.

#### Results

Cumulative weight losses were determined for each container as a function of time. The tanks underwent multiple diurnal cycles, but results are calculated using only the last five 24 hour cycles. The initial days of test data were not used in determining individual per container permeation rates due to high variability. A summary of all test results can be found in Attachment 2.

The average permeation rate from the 0.09 gallon 2-cycle chainsaw tank designated T1 was determined to be 1.31 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 5 gallon eXmark tank designated T3 was determined to be 0.55 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 1.4 gallon Murray tank designated T4 was determined to be 1.27 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 1.7 gallon Snapper tank designated T5 was determined to be 0.67 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 5 gallon Toro tank designated T7 was determined to be 0.77 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 5 gallon Tecumseh tank designated T11 was determined to be 0.64 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.08 gallon Echo tank designated T12 was determined to be 3.42 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.55 gallon Shindaiwa tank designated T13 was determined to be 2.26 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.38 gallon Stihl tank designated T14 was determined to be 0.72 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.74 gallon B&S tank designated T16 was determined to be 2.46 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.29 gallon Honda tank designated T17 was determined to be 4.57 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.12 gallon Honda tank designated T25 was determined to be 4.23 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

Attachment 1

1 Day / 24 Hour / 1440 Minute Variable Temperature Profile

HOUR	MINUTE	TIME REMAINING (MINUTES)	TEMPERATURE (°F)
0	0	1440	65.0
1	60	1380	66.6
2	120	1320	72.6
3	180	1260	80.3
4	240	1200	86.1
5	300	1140	90.6
6	360	1080	94.6
7	420	1020	98.1
8	480	960	101.2
9	540	900	103.4
10	600	840	104.9
11	660	780	105.0
12	720	720	104.2
13	780	660	101.1
14	840	600	95.3
15	900	540	88.8
16	960	480	84.4
17	1020	420	80.8
18	1080	360	77.8
19	1140	300	75.3
20	1200	240	72.0
21	1260	180	70.0
22	1320	120	68.2
23	1380	60	66.5
24	1440	0	65.0

#### Attachment 2

#### **PERMEATION TEST RESULTS**

February 2001

Diurnal Cycles	Tank		Tank	Treatment	Test	Fuel	Avg. Loss
(# 24 hr cycles)	Label	Mfg.	Volume	Level	Dates	Type	(g/gal/day)
5	T1	Husqvarna	0.09 gal	Untreated	2/06 - 2/17	CERT Mix	1.31
5	T3	Exmark	5 gal	Untreated	2/06 - 2/19	CERT	0.55
5	T4	Murray	1.4 gal	Untreated	2/06 - 2/17	CERT	1.27
5	T5	Snapper	1.7 gal	Untreated	2/06 - 2/17	CERT	0.67
5	T7	Toro	5 gal	Untreated	2/09 - 2/19	CERT	0.77
5	T11	Coleman	5 gal	Untreated	2/16 - 2/26	CERT	0.64
5	T12	Echo	0.08 gal	Untreated	2/06 - 2/17	CERT Mix	3.42
5	T13	Shindaiwa	0.55 gal	Untreated	2/06 - 2/17	CERT Mix	2.26
5	T14	Stihl	0.38 gal	Untreated	2/06 - 2/17	<b>CERT Mix</b>	0.72
5	T16	Maxim	0.74 gal	Untreated	2/06 - 2/17	<b>CERT Mix</b>	2.46
5	T17	Honda	0.29 gal	Untreated	2/06 - 2/17	CERT	4.57
5	T25	Honda	0.12 gal	Untreated	2/06 - 2/17	CERT	4.23
						Average	1.91

Label	T1				
Tare	456.75		Fuel Densi	ity	2810 grams/gallon
Davis	\\/:	\\//\f	Ob 2 2 2 2	Damasatian	
Day	Wi grams	•	Change	Permeation	
D1	697.82	697.70	0.12	1.40	
D2	697.22	697.16	0.06	0.70	
D3	697.16	697.11	0.05	0.58	
D4	697.11	696.99	0.12	1.40	
D5	696.99	696.91	0.08	0.94	
D6	696.91	696.84	0.07	0.82	
D7	696.84	696.70	0.14	1.64	
D8	696.70	696.57	0.13	1.52	
D9	696.57	696.45	0.12	1.41	
D10	696.45	696.35	0.10	1.17	
			Avg.	1.31	•
Label	Т3				
Tare	1813.4		Fuel Densi	ity	2791 grams/gallon
Day	Wi grams	Wf grams	Change	Permeation	
D1	13499.5	13498.9	0.60	0.14	
D2	13498.9	13498.2	0.70	0.17	
D3	13498.2	13496.9	1.30	0.31	
D4	13496.9	13495.3	1.60	0.38	
D5	13495.3	13493.6	1.70	0.41	
D6	13493.1	13490.7	2.40	0.57	
D7	13490.7	13488.6	2.10	0.50	
D8	13488.6	13486.1	2.50	0.60	
D9	13486.1	13483.9	2.20	0.53	
D10	13483.9	13481.6	2.30	0.55	
			Avg.	0.55	1
				0.00	

Label Tare	T4 664.03		Fuel Densi	itv	2791 grams/gallon
Taro	004.00		i dei Deiloi	ity	2701 grams/ganon
Day	Wi grams	Wf grams	Change	Permeation	
DÍ	4359.74	4358.32	1.42	1.07	
D2	4356.05	4354.95	1.10	0.83	
D3	4354.95	4353.49	1.46	1.10	
D4	4353.49	4351.89	1.60	1.21	
D5	4351.89	4350.30	1.59	1.20	
D6	4350.30	4348.64	1.66	1.26	
D7	4348.64	4346.94	1.70	1.29	
D8	4346.18	4344.45	1.73	1.31	
D9	4344.45	4342.87	1.58	1.20	
D10	4342.87	4341.19	1.68	1.27	
			Avg.	1.27	
Label	T5				
Tare					
Taic	1170.56		Fuel Densi	ity	2791 grams/gallon
				•	2791 grams/gallon
Day	Wi grams	Wf grams	Change	Permeation	2791 grams/gallon
Day D1	Wi grams 5473.89	5473.34	Change 0.55	Permeation 0.36	2791 grams/gallon
Day D1 D2	Wi grams 5473.89 5472.14	5473.34 5472.07	Change 0.55 0.07	Permeation 0.36 0.05	2791 grams/gallon
Day D1 D2 D3	Wi grams 5473.89 5472.14 5472.07	5473.34 5472.07 5471.50	Change 0.55 0.07 0.57	Permeation 0.36 0.05 0.37	2791 grams/gallon
Day D1 D2 D3 D4	Wi grams 5473.89 5472.14 5472.07 5471.50	5473.34 5472.07 5471.50 5470.69	Change 0.55 0.07 0.57 0.81	Permeation 0.36 0.05 0.37 0.53	2791 grams/gallon
Day D1 D2 D3 D4 D5	Wi grams 5473.89 5472.14 5472.07 5471.50 5470.69	5473.34 5472.07 5471.50 5470.69 5469.97	Change 0.55 0.07 0.57 0.81 0.72	Permeation 0.36 0.05 0.37 0.53 0.47	2791 grams/gallon
Day D1 D2 D3 D4 D5 D6	Wi grams 5473.89 5472.14 5472.07 5471.50 5470.69 5469.97	5473.34 5472.07 5471.50 5470.69 5469.97 5469.12	Change 0.55 0.07 0.57 0.81 0.72 0.85	Permeation 0.36 0.05 0.37 0.53 0.47 0.55	2791 grams/gallon
Day D1 D2 D3 D4 D5 D6 D7	Wi grams 5473.89 5472.14 5472.07 5471.50 5470.69	5473.34 5472.07 5471.50 5470.69 5469.97	Change 0.55 0.07 0.57 0.81 0.72 0.85 1.01	Permeation 0.36 0.05 0.37 0.53 0.47 0.55 0.66	2791 grams/gallon
Day D1 D2 D3 D4 D5 D6 D7 D8	Wi grams 5473.89 5472.14 5472.07 5471.50 5470.69 5469.97	5473.34 5472.07 5471.50 5470.69 5469.97 5469.12 5468.11 5466.68	Change 0.55 0.07 0.57 0.81 0.72 0.85 1.01 1.04	Permeation 0.36 0.05 0.37 0.53 0.47 0.55 0.66 0.68	2791 grams/gallon
Day D1 D2 D3 D4 D5 D6 D7 D8 D9	Wi grams 5473.89 5472.14 5472.07 5471.50 5470.69 5469.97 5469.12 5467.72 5466.68	5473.34 5472.07 5471.50 5470.69 5469.97 5469.12 5468.11 5466.68 5465.62	Change 0.55 0.07 0.57 0.81 0.72 0.85 1.01 1.04 1.06	Permeation 0.36 0.05 0.37 0.53 0.47 0.55 0.66 0.68 0.69	2791 grams/gallon
Day D1 D2 D3 D4 D5 D6 D7 D8	Wi grams 5473.89 5472.14 5472.07 5471.50 5470.69 5469.97 5469.12 5467.72	5473.34 5472.07 5471.50 5470.69 5469.97 5469.12 5468.11 5466.68	Change 0.55 0.07 0.57 0.81 0.72 0.85 1.01 1.04	Permeation 0.36 0.05 0.37 0.53 0.47 0.55 0.66 0.68	2791 grams/gallon

T7				
2129.2		Fuel Densi	ity	2791 grams/gallon
\	\	Ol	D	
•	•	_		
		_		
11798.1		1.3		
11796.8	11794.9	1.9	0.55	
11794.9	11792.8	2.1	0.61	
11792.0	11789.5	2.5	0.72	
11789.5	11787.0	2.5	0.72	
11787.0	11784.2	2.8	0.81	
11784.2	11781.3	2.9	0.84	
11781.3	11778.6	2.7	0.78	
		Avg.	0.77	
T11				
T11 2517.4		Fuel Dens	ity	2791 grams/gallon
		Fuel Dens	ity	2791 grams/gallon
2517.4	Wf grams	Fuel Dens	ity Permeation	2791 grams/gallon
2517.4				2791 grams/gallon
2517.4 Wi grams	Wf grams 14253.7	Change	Permeation	2791 grams/gallon
2517.4 Wi grams 14255.6	Wf grams 14253.7 14251.8	Change 1.9	Permeation 0.45	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7	Wf grams 14253.7 14251.8 14249.7	Change 1.9 1.9	Permeation 0.45 0.45	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7 14251.8	Wf grams 14253.7 14251.8 14249.7 14248.0	Change 1.9 1.9 2.1	Permeation 0.45 0.45 0.50	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7 14251.8 14249.7	Wf grams 14253.7 14251.8 14249.7 14248.0 14245.4	Change 1.9 1.9 2.1 1.7	Permeation 0.45 0.45 0.50 0.40 0.62	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7 14251.8 14249.7 14248.0	Wf grams 14253.7 14251.8 14249.7 14248.0 14245.4 14242.7	Change 1.9 1.9 2.1 1.7 2.6 2.7	Permeation 0.45 0.45 0.50 0.40 0.62 0.64	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7 14251.8 14249.7 14248.0 14245.4	Wf grams 14253.7 14251.8 14249.7 14248.0 14245.4 14242.7 14238.7	Change 1.9 1.9 2.1 1.7 2.6 2.7 2.7	Permeation 0.45 0.45 0.50 0.40 0.62 0.64 0.64	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7 14251.8 14249.7 14248.0 14245.4 14241.4 14238.7	Wf grams 14253.7 14251.8 14249.7 14248.0 14245.4 14242.7 14238.7 14236.1	Change 1.9 1.9 2.1 1.7 2.6 2.7 2.7 2.6	Permeation 0.45 0.45 0.50 0.40 0.62 0.64 0.64 0.62	2791 grams/gallon
2517.4 Wi grams 14255.6 14253.7 14251.8 14249.7 14248.0 14245.4 14241.4	Wf grams 14253.7 14251.8 14249.7 14248.0 14245.4 14242.7 14238.7 14236.1 14233.2	Change 1.9 1.9 2.1 1.7 2.6 2.7 2.7	Permeation 0.45 0.45 0.50 0.40 0.62 0.64 0.64	2791 grams/gallon
	Wi grams 11800.2 11799.8 11798.1 11796.8 11794.9 11792.0 11789.5 11787.0 11784.2	Wi grams Wf grams 11800.2 11799.8 11799.8 11798.1 11798.1 11796.8 11796.8 11794.9 11794.9 11792.8 11792.0 11789.5 11789.5 11787.0 11787.0 11784.2 11784.2 11781.3 11781.3 11778.6	Wi grams Wf grams Change 11800.2 11799.8 0.4 11799.8 11798.1 1.7 11798.1 11796.8 1.3 11796.8 11794.9 1.9 11794.9 11792.8 2.1 11792.0 11789.5 2.5 11789.5 11787.0 2.5 11787.0 11784.2 2.8 11784.2 11781.3 2.9	Wi grams Wf grams Change Permeation 11800.2 11799.8 0.4 0.12 11799.8 11798.1 1.7 0.49 11798.1 11796.8 1.3 0.38 11796.8 11794.9 1.9 0.55 11794.9 11792.8 2.1 0.61 11792.0 11789.5 2.5 0.72 11789.5 11787.0 2.5 0.72 11787.0 11784.2 2.8 0.81 11784.2 11781.3 2.9 0.84 11781.3 11778.6 2.7 0.78

Label	T12				
Tare	147.45		Fuel Densi	ity	2810 grams/gallon
-	147	144	01	5	
Day	Wi grams	•	Change	Permeation	
D1	356.32	356.17	0.15	2.02	
D2	355.93	355.75	0.18	2.43	
D3	355.75	355.58	0.17	2.29	
D4	355.58	355.35	0.23	3.11	
D5	355.35	355.13	0.22	2.97	_
D6	355.13	354.91	0.22	2.98	
D7	354.91	354.66	0.25	3.39	
D8	354.55	354.29	0.26	3.53	
D9	354.29	354.03	0.26	3.53	
D10	354.03	353.76	0.27	3.67	
		'	Avg.	3.42	
Label	T13				
Label Tare	T13 548.65		Fuel Densi	ity	2810 grams/gallon
			Fuel Densi	-	2810 grams/gallon
		Wf grams	Fuel Densi	ity Permeation	2810 grams/gallon
Tare	548.65	Wf grams 1792.84		-	2810 grams/gallon
Tare Day	548.65 Wi grams	•	Change	Permeation	2810 grams/gallon
Tare Day D1	548.65 Wi grams 1793.31	1792.84	Change 0.47	Permeation 1.06	2810 grams/gallon
Tare Day D1 D2	548.65 Wi grams 1793.31 1792.06	1792.84 1791.46	Change 0.47 0.60	Permeation 1.06 1.36	2810 grams/gallon
Tare  Day D1 D2 D3	548.65 Wi grams 1793.31 1792.06 1791.46	1792.84 1791.46 1790.87	Change 0.47 0.60 0.59	Permeation 1.06 1.36 1.33	2810 grams/gallon
Day D1 D2 D3 D4	548.65 Wi grams 1793.31 1792.06 1791.46 1790.87	1792.84 1791.46 1790.87 1790.08	Change 0.47 0.60 0.59 0.79	Permeation 1.06 1.36 1.33 1.79	2810 grams/gallon
Day D1 D2 D3 D4 D5	548.65 Wi grams 1793.31 1792.06 1791.46 1790.87 1790.08	1792.84 1791.46 1790.87 1790.08 1789.31	Change 0.47 0.60 0.59 0.79 0.77	Permeation 1.06 1.36 1.33 1.79 1.74	2810 grams/gallon
Day D1 D2 D3 D4 D5 D6	548.65 Wi grams 1793.31 1792.06 1791.46 1790.87 1790.08 1789.31	1792.84 1791.46 1790.87 1790.08 1789.31 1788.45	Change 0.47 0.60 0.59 0.79 0.77	Permeation 1.06 1.36 1.33 1.79 1.74	2810 grams/gallon
Day D1 D2 D3 D4 D5 D6 D7	548.65 Wi grams 1793.31 1792.06 1791.46 1790.87 1790.08 1789.31 1788.45	1792.84 1791.46 1790.87 1790.08 1789.31 1788.45 1787.50	Change 0.47 0.60 0.59 0.79 0.77 0.86 0.95	Permeation 1.06 1.36 1.33 1.79 1.74 1.95 2.15	2810 grams/gallon
Day D1 D2 D3 D4 D5 D6 D7 D8	548.65 Wi grams 1793.31 1792.06 1791.46 1790.87 1790.08 1789.31 1788.45 1787.08	1792.84 1791.46 1790.87 1790.08 1789.31 1788.45 1787.50 1786.06	Change 0.47 0.60 0.59 0.79 0.77 0.86 0.95 1.02	Permeation 1.06 1.36 1.33 1.79 1.74 1.95 2.15 2.31	2810 grams/gallon

Label Tare	T14 1174.80		Fuel Densi	itv	2810 grams	s/gallon
raio	117 1.00		1 401 501101	· · ·	2010 graine	, ganon
Day	Wi grams	Wf grams	Change	Permeation		
DÍ	2249.71	2249.54	0.17	0.44		
D2	2248.38	2248.23	0.15	0.39		
D3	2248.23	2248.11	0.12	0.31		
D4	2248.11	2247.88	0.23	0.60		
D5	2247.88	2247.71	0.17	0.45		
D6	2247.71	2247.53	0.18	0.47		
D7	2247.53	2247.20	0.33	0.86		
D8	2247.24	2246.90	0.34	0.89		
D9	2246.90	2246.61	0.29	0.76		
D10	2246.61	2246.37	0.24	0.63		
			Avg.	0.72	Std. Dev.	0.07
Label	T16					
Tare	665.76		Fuel Densi	ty	2791 grams	s/gallon
Day	•	Wf grams	Change	Permeation		
D1	2589.18	2587.87	1.31	1.90		
D2	2585.96	2584.62	1.34	1.95		
D3	2584.62	2583.11	1.51	2.20		
D4	2583.11	2581.52	1.59	2.31		
D5	2581.52	2579.92	1.60	2.33	_	
D6	2579.92	2578.30	1.62	2.36		
D7	2578.30	2576.64	1.66	2.42		
D8	2575.90	2574.20	1.70	2.48		
D9	2574.20	2572.64	1.56	2.28		
D10	2572.64	2570.77	1.87	2.74		
			Avg.	2.46	Std. Dev.	0.12

T17				
581.78		Fuel Densi	ity	2791 grams/gallon
•	•	-		
1331.78	1330.80	0.98	3.65	
1329.37	1328.38	0.99	3.70	
1328.38	1327.34	1.04	3.89	
1327.34	1326.12	1.22	4.57	
1326.12	1324.95	1.17	4.39	
1324.95	1323.80	1.15	4.32	
1323.80	1322.59	1.21	4.55	
1322.04	1320.80	1.24	4.68	
1320.80	1319.55	1.25	4.72	
1319.55	1318.34	1.21	4.58	
	'	Avg.	4.57	
		Ū		
T25				
216.59		Fuel Densi	ity	2791 grams/gallon
Wi grams	Wf grams	Change	Permeation	
564.79	564.44	0.35	2.81	
563.90	563.54	0.36	2.89	
563.54	563.12	0.42	3.38	
563.12	562.66	0.46	3.70	
562.66	562.17	0.49	3.95	
302.00	302.17	0.49	5.95	
562.17	561.70	0.49	3.80	
562.17	561.70	0.47	3.80	
562.17 561.70 560.94	561.70 561.18	0.47 0.52	3.80 4.21	
562.17 561.70	561.70 561.18 560.39	0.47 0.52 0.55	3.80 4.21 4.46	
	581.78 Wi grams 1331.78 1329.37 1328.38 1327.34 1326.12 1324.95 1323.80 1322.04 1320.80 1319.55  T25 216.59 Wi grams 564.79 563.90 563.54 563.12	581.78 Wi grams Wf grams 1331.78 1330.80 1329.37 1328.38 1328.38 1327.34 1327.34 1326.12 1326.12 1324.95 1324.95 1323.80 1323.80 1322.59 1322.04 1320.80 1320.80 1319.55 1319.55 1318.34  T25 216.59 Wi grams Wf grams 564.79 564.44 563.90 563.54 563.12 562.66	581.78         Fuel Density           Wi grams         Wf grams         Change           1331.78         1330.80         0.98           1329.37         1328.38         0.99           1328.38         1327.34         1.04           1327.34         1326.12         1.22           1326.12         1324.95         1.17           1324.95         1323.80         1.15           1323.80         1322.59         1.21           1320.80         1319.55         1.25           1319.55         1318.34         1.21           Avg.         Avg.           T25         Fuel Densi           Wi grams         Wf grams         Change           564.79         564.44         0.35           563.90         563.54         0.36           563.54         563.12         0.42           563.12         562.66         0.46	581.78         Fuel Density           Wi grams         Wf grams         Change         Permeation           1331.78         1330.80         0.98         3.65           1329.37         1328.38         0.99         3.70           1328.38         1327.34         1.04         3.89           1327.34         1326.12         1.22         4.57           1326.12         1324.95         1.17         4.39           1324.95         1323.80         1.15         4.32           1323.80         1322.59         1.21         4.55           1322.04         1320.80         1.24         4.68           1320.80         1319.55         1.25         4.72           1319.55         1318.34         1.21         4.58           Avg.         4.57           T25           216.59         Fuel Density           Wi grams         Wf grams         Change         Permeation           564.79         564.44         0.35         2.81           563.90         563.54         0.36         2.89           563.54         563.12         0.42         3.38           563.12         562.66         0.46<